RDT

Brief

Research Investigation 96-025

January, 2005

Diamond Grinding Newly Placed PCCP

Introduction

In 1996, MoDOT began reviewing a proposal to use diamond grinding as a means to provide texture and a smooth profile in place of a transversely tined finish on newly constructed Portland cement concrete pavement (PCCP). Research suggests the smoother a pavement is initially; the better it will perform over time and the longer it will last. Diamond grinding can lower the profile index by 50% or more on newly constructed pavement and could produce a very smooth ride.

Two projects have been completed in Missouri that are currently being evaluated. Data collected for this evaluation consists of visual distress surveys, profilograph measurements, Automated Road Analyzer data (ARAN), Falling Weight Deflectometer data (FWD), and friction testing. The surveys and tests are performed on a yearly basis.

Project Descriptions

Route 60, Butler County

The Route 60, Butler County project was constructed in 1997 and the pavement design included 12-inch, non-reinforced Portland Concrete Cement (PCC) pavement and shoulders. Dowelled transverse joints were spaced at 15 feet. Following the placement and finishing of the slip-formed pavement in the eastbound lanes, the newly placed surface received initial texturing with a burlap drag. The burlap drag provided an interim textured surface following placement and prior to diamond grinding. Approximately 21 days following the paving operation, only the travel lanes were diamond ground, leaving the shoulders with the burlap drag finish. The eastbound lanes received the diamond ground finish while the westbound lanes were finished using the conventional transverse tining. For our evaluation, three 600-foot test sections were set up within the diamond ground sections in the eastbound lanes, while two 600-foot test sections were set up within the transversely tined section in the westbound lanes.

I-44, Webster/Greene Counties

In an effort to obtain more information on the technique of diamond grinding newly placed PCC pavement, Research is monitoring approximately six miles of an 8 inch PCC overlay in the westbound lanes of I-44 in Webster and Greene counties that was constructed in 2000. Total width of the 8 inch, non-reinforced, and unbonded overlay, including shoulders, is 38 feet, with dowelled transverse joints spaced at 15 feet. Like the Route 60 project, following the placement and finishing of the slip-formed overlay, the newly placed surface received initial texturing with a burlap drag. The burlap drag provided an interim textured surface following placement and prior to diamond grinding. Approximately 21 days following the paving operation, only the travel lanes were diamond ground, leaving the shoulders with the burlap drag finish.

Research Development and Technology

Missouri Department of Transportation

1617 Missouri Blvd.
P.O. Box 270
Jefferson City,
Missouri 65101

Three 1,000-foot test sections were set up within the six-mile project and selected for visual distress surveys, profilograph measurements, ARAN data, and friction tests. Due to the heavy volume of high-speed traffic, only the driving lane is being monitored for profilograph measurement, ARAN data, and friction tests.

Visual Distress Survey

Route 60, Butler County
Both the driving lane and passing lane in all test sections were visually inspected thru 2003, the sixth year after the pavement was opened to traffic. Of the 3600 lane feet surveyed in the diamond ground sections, only three low severity two-foot cracks have been observed to date, two longitudinal and one transverse. There was no evidence of any joint problems, such as faulting or spalling. The raised joint sealant that was reported earlier is wearing down, giving the impression of a smoother ride.

In the tined pavement test sections, of the 2400 lane feet surveyed, no cracks were observed. In fact, there has been no evidence of the block cracking as was reported in 2001, possibly due to the lack of moisture to the area. There was no evidence of joint problems.

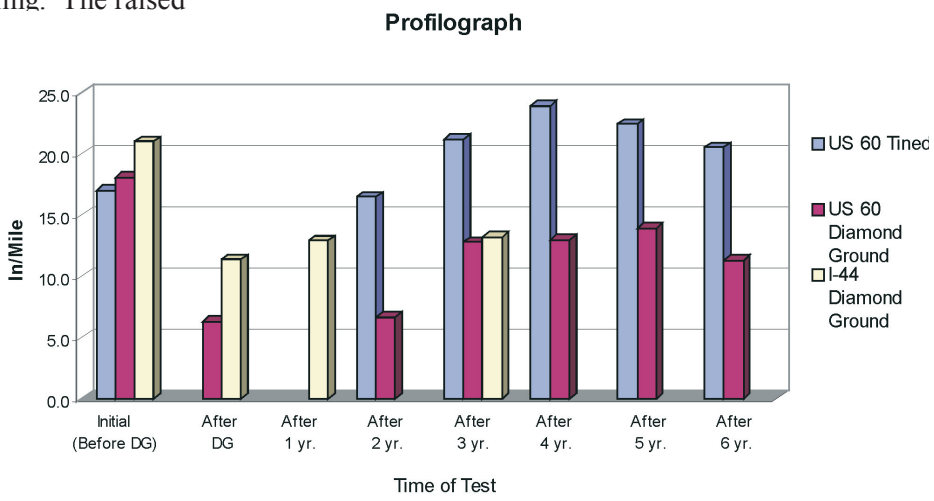
I-44, Webster/Greene Counties
Both the driving and passing lanes in all three sections were visually inspected prior to diamond grinding operations on the newly placed pavement. No cracks or joint problems were observed. Approximately one month after the diamond grinding operations were completed, another visual distress survey was performed. One 12-foot long, low severity transverse crack, located approximately nine inches from a joint in test section #2 was found in the driving lane and one three foot long, low severity transverse crack, approximately nine inches from another joint in test section #2 was found in the passing lane. Both cracks were located on the lead-out side of the joint in test section #2. These cracks have been routed and sealed and are the only cracks that have been found to date.

Profilograph Measurements

Route 60, Butler County
There has been a slight steady increase in the profilograph measurements through all five-test sections during the six years of service, except for last year where there was a slight decrease from the previous three years. The eastbound diamond ground test sections averaged 11.3 inches per mile, compared to 12.8 inches per mile three years earlier. The westbound tined sections averaged 20.5 inches per mile, compared to 21.2 inches per mile three years earlier. The diamond ground sections continue to have lower profilograph numbers than the tined sections.

I-44, Greene/Webster Counties
Profilograph measurements were taken in both the driving lane and passing lane before and after the diamond grinding operation was performed. The average profilograph measurement was 26.8 inches per mile before diamond grinding, 11.4 inches per mile after diamond grinding, and 13.2 inches per mile after three years of service.

The following chart shows all the profilograph averages since construction for both projects:



Automated Road Analyzer (ARAN)

Route 60, Butler County
The pavement serviceability rating (PSR) for the diamond ground pavement is 35.1, slightly down from 35.8 six years prior. The PSR for the tined pavement is 34.7, up from the original 34.1. The PSR is determined by rating the joints, cracks, spalls, and patches from 0 to 5, with the combination of these measures incorporated with the pavement's measured ride number. Pavements are rated on a scale of 0 to 40, with the higher number indicating a pavement with a better surface and ride. The average International Roughness Index (IRI) for the diamond ground section dropped slightly from 62.4 in 1997 to 60.6 six years later, while the tined section dropped from 91.8 to 75.4. MoDOT purchased a new ARAN van and software in 2001, which could explain the dramatic drop in IRI numbers from 2000 to 2001. The IRI is a nationally based number to measure pavement smoothness and compares the pavement to other pavements throughout the United States. The scale for the IRI ranges from 0 to 300. Lower values indicate improved

smoothness or better ride as compared to higher IRI values. Following is a list of IRI values and how they've been found to correspond to roughness:

Approximate IRI *inches/mile*	Roughness Classification
0-95	Smooth
95-133	Moderately Rough
>133	Rough

I-44, Webster/Greene Counties
The PSR for the diamond ground overlay is 36.6, down from the previous of 36.7. The IRI rose slightly from 36.8 to 39.4. ARAN data for both projects can be found in Table 1.

Table 1

Route 60						I-44	
Diamond Ground IRI	PSR	IRI	Tined	PSR	IRI	Diamond Ground	PSR
Aug 1997 36.8	35.3	72.7	1997	34.1	91.8	2002	36.7
Nov 1997 39.4	35.8	62.4	1998	34.8	58.1	2003	36.6
1998	36.4	77.6	1999	33.9	82.0		
1999	35.1	87.2	2000	35.2	81.9		
2000	35.2	89.5	2001	36.5	68.6		
2001	36.1	64.3	2002	-----	52.7		
2002	-----	49.3	2003	34.7	75.4		
2003	35.1	60.6					

Falling Weight Deflectometer

Route 60, Butler County
FWD testing indicates that all deflection basin areas were above an average of 30, which indicates very sound pavement structure. The averages for concrete should fall in the range of 24 to 33, with 33 representing the soundest pavement structure. The average maximum deflections were below 3 mil. Low average maximum deflections are a product of thick PCC and stable base support. Average load transfers on Route 60 indicate good distribution of weight across the joints. Low average maximum deflections probably explain any loss of load transfer as primarily the result of small cast-in place voids around the dowel bars rather than any subsequent deterioration.

I-44, Webster/Greene Counties
Due to this project being an unbonded concrete overlay, no FWD data will be collected. It is felt that since the original pavement had 61.5-foot joint spacing and the overlay has 15-foot joint spacing, load transfer readings would be meaningless. Also, the deflection readings would be very low because of the underlying concrete pavement.

Friction Properties

Route 60, Butler County
The friction values have shown a slight decrease during the six years of service in both the diamond ground and the tined sections. The eastbound diamond ground sections have declined from 52.2 to 49.9 during the six years of service, while the westbound tined sections have dropped from 56.3 to 54.3. While the friction numbers may be lower, they still indicate good friction properties.

I-44, Webster/Greene Counties
Friction data was collected prior to and after diamond grinding operations were completed, but before the pavement was opened to traffic. The friction values averaged 30.9 before diamond grinding and 52.1 after diamond grinding. The friction numbers collected before the diamond grinding operation should be viewed with some reservation, because there was some residual curing compound left on the driving surface. The friction numbers after diamond grinding indicate good friction properties.

Friction data collected in September 2001 indicated a dramatic drop in friction properties after the project was opened to traffic. Friction numbers dropped from 52.1 down to 27.2, a 48 percent decrease and a value much lower than that typically expected. Further investigation into this unexpected drop in friction numbers has identified the coarse aggregate as a possible contributing factor. The LA abrasion loss for the aggregate used on I-44 was 41 percent. While this is within our specification of less than 50 percent, it is much higher than the aggregate used on the Route 60 project, where the LA abrasion loss for the aggregate used was 26 percent. Other states have indicated that when diamond grinding "softer" aggregates, the grooves should be spread farther apart to increase the integrity of the diamond ground surface. MoDOT specifications for diamond grinding have since been modified to address this issue.

The friction values have shown an increase after the first year of service and in 2002 were up to 29.1.

Conclusions

Route 60, Butler County
After six years of service, the Route 60, Butler County project continues to perform well. The diamond ground and tined sections show only minor pavement distress and no joint problems. Both pavements ride smoothly,

but the diamond grinding to date maintains a smoother ride than the tined pavement. After six years of service, the diamond ground pavement continues to maintain a lower profile index than the tined pavement. The ARAN data implies that the diamond ground pavement sustains a higher PSR than the tined pavement over time.

I-44, Webster/Greene Counties

After three years of service, the I-44 Webster/Greene County project is performing well. The project has only minor pavement distress, no joint problems, and continues to ride smooth. While friction values may be low, they are showing some improvement.

Based on the observations and results of this study to date, diamond grinding is a viable method for providing surface smoothness and texture to newly placed PCCP, and it sustains pavement smoothness longer than conventional texture methods.

For more information, contact

John P. Donahue
Pavement Engineer
Construction and Materials
Missouri DOT
1617 Missouri Blvd.
Jefferson City, Mo. 65102
Telephone:(573)526-4334
Fax:(573)526-4337
email: John.Donahue@MoDOT.mo.gov

Dave Amos
Senior Research and Development Assistant
Missouri DOT
1617 Missouri Blvd.
Jefferson City, Mo. 65109
Telephone: (573) 526-4316 Cell: (573) 690-4067
Fax: (573) 526-4337
email:David.Amos@MoDOT.mo.gov

Missouri Department of Transportation
Research, Development and Technology
1617 Missouri Blvd.
P.O. Box 270
Jefferson City, MO 65102

Phone: (573) 751-3002
1-888-ASK MODOT
Email: rdtcomments@modot.mo.gov
Web Address: www.modot.org/services/rdt